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LOCKHEED MARTIN

DATE: October 1, 2009

TO: Gary Newhart, U.S. EPA/ERTC Work Assignment Manager

THROUGH: Dennis Miller, REAC Program Manager

FROM: Christopher Gussman, REAC Task Leader

SUBJECT: PILOT STUDY SEPTEMBER 2009 EVALUATION
LOWER SILVER CREEK TAILINGS SITE
WORK ASSIGNMENT No. 0-300
TRIP REPORT

Introduction

This trip report summarizes the progress of the pilot scale study at the Lower Silver Creek Tailings Site initiated on May 11, 2009. In November of 2008, Lockheed Martin Response Engineering Analytical Contract (REAC) personnel were tasked to chemically and agriculturally characterize soil provided from the site. Part of this evaluation was to determine the effect of a locally available biosolids compost source and another organic compost on the soil chemistry and plant growth in these soils. Contaminated soil (tailings) cover a large area of the site, and an effective way to revegetate the area and/or bind metals of interest would be more economic than removal. The current goal is to observe the effects of the amendment in the field *in situ*, and to compare different amendments and amendment application rates on the growth and long term establishment of the native revegetation effort.

REAC personnel, the U.S. Environmental Protection Agency (U.S. EPA) Work Assignment Management (WAM), and a representative of the U.S. Fish and Wildlife Service, under guidance of Region VIII EPA, initiated the pilot scale trial on May 11, 2009. An area of tailings typical of the area was selected, and a 75 feet by 100 feet pilot study area was created. This pilot study area was divided into fifteen 25 feet by 20 feet subplots allowing five treatments placed by a complete randonized block design with three replications. An additional, smaller experimental plot (five 10 feet by 10 feet blocks, not replicated) was also set up on an area of barren tailings.

On September 16, 2009 the REAC task leader and the ERT WAM returned to the Site to evaluate the progress of the revegetation establishment at the Site after the first full growing season.

Background

From the mid-1800s through the 1970s, this region was extensively mined for silver and lead ores. Although some remediation has occurred, residual deposits of tailing wastes remain in place along large sections of the Lower Silver Creek. Bed sediment samples were collected by the USGS in 1998, 1999, and 2000 and analyzed. Water samples were collected in March and August 2000 and were analyzed for total and dissolved trace metals.

Concentrations of silver (Ag), cadmium (Cd), copper (Cu), lead (Pb), mercury (Hg), and zinc (Zn) in the streambed sediment of Silver Creek greatly exceeded background concentrations. The levels of these metals also exceeded established aquatic life criteria at most sites. In the Weber River, downstream of the confluence with Silver Creek, concentrations of Cd, Pb, Zn, and total Hg in streambed sediment also exceeded aquatic life guidelines, however,

concentrations of metals in streambed sediment of McLeod and Kimball Creeks were lower than Silver Creek. Water-column sampling showed concentrations of Zn, total Hg, and methylmercury in Silver Creek were high relative to unimpacted sites, and exceeded water quality criteria for the protection of aquatic organisms. Qualitative measurements of the macroinvertebrate community in Silver Creek were compared to the spatial distribution of metals in streambed sediment. The data indicate that impairment related to metal concentration exists in Silver Creek.

The Lower Silver Creek Tailings Site extends over 12 miles along the banks of Silver Creek, from State Route 248 north of Richardson Flat, two miles east of Park City, Summit County, Utah. The site has been subdivided into southern and northern portions, due to the site conditions and topography. The northern portion of the site consists of a narrow corridor located between the lanes of interstate 80 (I-80) which includes the rail trail, Silver Creek and the riparian habitat. The southern portion of the site is approximately 4.4 miles in length between Atkinson and State Route 248, and is as much as 2,500 wide, east to west. The southern portion of the site upstream from Atkinson is being developed by residential and commercial expansion.

The headwaters of Silver Creek are located upgradient of Park City. Silver Creek is the primary drainage within the watershed downstream to the Weber River confluence in Wanship, Utah. The Weber River is considered a Class 4 (agricultural), 3A (cold water fishery), 2B (contact recreation), and 1C (source of drinking water) river. Silver Creek is considered a Class 3A, 1C and 4 stream.

Mine tailings generally cover the entire southern portion of the Lower Silver Creek. Tailings are readily apparent in the non-vegetated gray colored sandy and gravelly mounds and low ridges within the riparian habitat along Silver Creek. Elongated berms trend north-south and are found throughout the entire southern portion of the Lower Silver Creek.

The northern portion of the Lower Silver Creek is a generally well vegetated riparian habitat. A beaver dam was observed upstream from Alexander Canyon. Fish were observed in Silver Creek at a few locations. Various bird species have been reported along the banks of the Silver Creek. Mine tailings have reportedly not been observed more than one mile north and downstream of Atkinson.

The area impacted by this Site is too large for conventional treatment such as removal. It is anticipated that compost and possibly other soil amendments may be utilized to enhance vegetative cover establishment at the site and possibly reduce mobility of the metal contaminants. In January 2008, REAC scientists performed a laboratory test to examine growth of plants and metal concentration on four soil samples obtained from Lower Silver Creek. The studies indicated that the plant growth was problematic but plant health and vitality were improved with supplemental compost and phosphorus. The next step was to conduct a pilot scale revegetation trial on the tailings *in situ*. Plant growth and species diversity could then be observed under natural site conditions and any potential problems identified and corrected before going full scale. Additional data, such as metal mobility and carbon sequestration rates may also be obtained from these pilot plots at a future date.

The pilot study commenced in May 2009. In July 2009 the REAC task leader, ERT WAM and U.S. Fish and Wildlife Service representative returned to the Site to evaluate the initial growth and establishment of vegetation and check the overall status of the Site. The plots were in good shape, and the seedlings were growing well on the amended plots. Photographs were obtained of each plot and percent vegetative coverage was recorded. Results were included in the July 2009 trip report.

Current Activities

The REAC Task Leader and the WAM arrived at the site on the afternoon of Wednesday, September 16, 2009. The overall condition of the Site was good. Difference in vegetative growth on different plots (soil amendments) were still apparent, but the plants had browned and had already gone dormant both in the plot and in the surrounding areas. The dominant rush "wiregrass (*Juncus balticus*) still showed some green, but most of the grasses and forbs were already dormant and brown above ground (Figure 1).

To evaluate and compare the different treatments, it was desired to look at vegetative cover and above ground plant biomass at the end of this first growing season. Unfortunately, much of the germinated seed mixture had already died back, and some of the above ground plant material was already decayed and lost. However, it was observed that many of the grasses were dormant and demonstrated healthy root systems (Figure 2). These perennials will regrow during the 2010 growing season.

Percent vegetative cover and biomass was still evaluated, as the treatment difference could still be observed. However, these results may be biased towards the wiregrass which was still green and in better physical shape than many of the other grasses and forbs. Where possible, intact but brown remains of grasses and forbs were also included in the measurements.

Three locations within each treatment plot were preselected using randomly selected coordinates. The same three coordinate locations were used within each treatment cell. For each 25 feet by 20 feet treatment cell, the southwest corner was selected as the 0,0 coordinate. The three locations were set up at (7.5', 12'), (10', 5'), and (20', 15') and labeled as locations 1, 2 and 3 respectively. These locations were flagged, and a one meter (m) by one m quadrat was placed around each flag. This one m square quadrat was further divided into four equal quarters. Percent vegetative cover was recorded for each of the four quarters of each quadrat. All above ground vegetation in the southeast quarter was cut one centimeter above ground surface and shipped back to the REAC biology laboratory. Once received at the laboratory, the plant samples were placed into paper bags and dried in an oven at 70 degrees centigrade for two days. Afterwards, the dry plant material was weighed and the weight (in grams) recorded.

Table 1 (below) illustrates the average percent (%) vegetative coverage and dry weight in grams (g) per treatment. The dry weight is the average for one quarter of a square meter. Field notes and raw data may be found in Appendix A.

Table 1: September 2009 Average Vegetation Coverage and Dry Weight at the Lower Silver Creek Pilot Study.

Soil Amendment Treatment	Average Percent Vegetative Coverage.	Average Dry Weight in Grams per 0.25 Square Meter.
Treatment A (Control)	7.08	7.93
Treatment B (10% Biosolids Compost)	21.25	16.53
Treatment C (20% Biosolids Compost)	21.39	10.8
Treatment D (10% Leaf Compost)	8.61	6.43
Treatment E (10% Biosolids + 10% Leaf Composts)	24.3	15.21

It is apparent that the addition of organic material, particularly biosolids compost, has a positive effect on vegetative growth on the tailings at Lower Silver Creek. The differences with treatment could be readily observed on Site even when standing on the adjacent road. Thus far, treatments B, C, and E appear to have a very similar, positive effect on stimulating plant growth, and these three treatments performed much better than the untreated control. Treatment D, leaf compost only, produced rather poor results, perhaps because this compost is deficient in nitrogen.

Future Activities

Future of the amended soils to bind metals of concern, and carbon sequestration will be more closely examined. It is anticipated that another trip will be made to the site in May or June 2010 for further evaluation. Additional treatments may also be evaluated in the field or laboratory based on current findings and additional discussion.

Figures

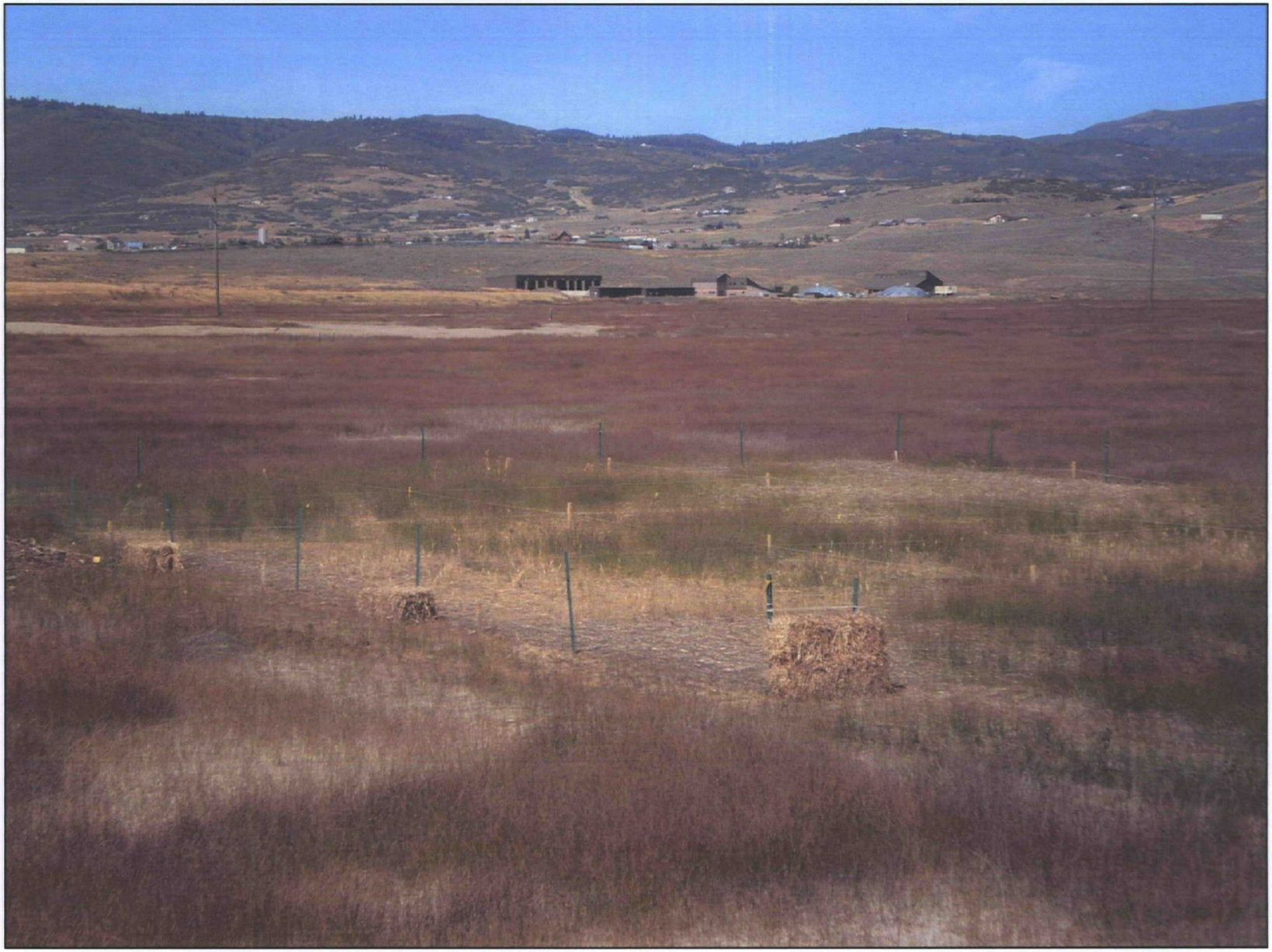


FIGURE 1
THE PILOT AREA SEPTEMBER 2009,
AFTER ONE GROWING SEASON
LOWER SILVER CREEK TAILING SITE
PARK CITY, UTAH
SEPTEMBER 2009

U.S. EPA ENVIRONMENTAL RESPONSE TEAM
RESPONSE ENGINEERING AND ANALYTICAL CONTRACT
EP-C-04-032
W.A.# 0 - 300

09/2009
REAC4/300/300_FIG1_092009.DWG

FIGURE 2
DORMANT GRASS PLANT WITH,
HEALTHY ROOT SYSTEM
LOWER SILVER CREEK TAILING SITE
PARK CITY, UTAH
SEPTEMBER 2009

U.S. EPA ENVIRONMENTAL RESPONSE TEAM
RESPONSE ENGINEERING AND ANALYTICAL CONTRACT
EP-C-04-032
W.A.# 0 - 300

Appendix A

Appendix A
September 2009 Field Notes and Calculations
Lower Silver Creek Tailings Site
October 1, 2009

REAC IV-B-0347

"Rite in the Rain"®
ALL-WEATHER
FIELD
No. 351

LOWER SILVER CREEK

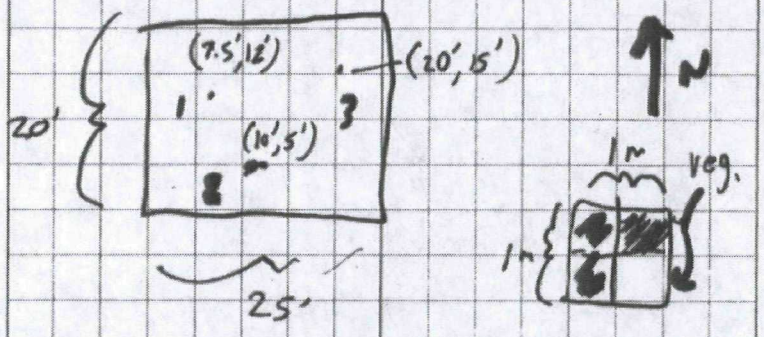
WA # 0-300

T.L = C. Gussman

9/16/09 Wednesday

Depart Reno 4:45 A.M., Delta flight at 7:05 A.M.

Returning to L.S.C. to check the status of the pilot plots after one growing season. T.C. Christopher Gustavson to meet EPA/ERT team Gary Newhart in Utah. Revegetation and plant biomass to be examined at three, previously selected random coordinates ... the same coordinates within each plot.

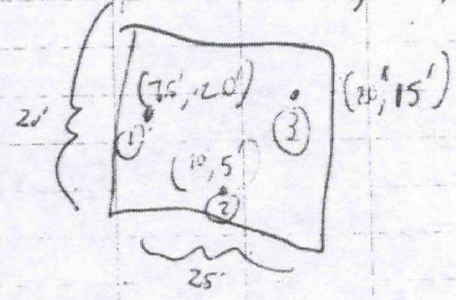


A pin flag will be placed at each coordinate, and a quadrat of 1m x 1m set up at this location. The biomass of vegetation of the quadrat will be weighed (fresh weight) then dried and weighed again (dry weight). Veg cover and notes on all 3 quadrats noted. Vegetation cut 2cm above soil surface

Checked into hotel, · lost bars from father missing. Delayed in transit so will be delivered tomorrow. Stopped at Home Depot to replace shears, tape measure.

Site further generated than anticipated. Wiregrass still has some green but all true grass now brown.... biomass almost non-existent as well as green coverage. However, bases and roots of some of the grasses still look good, some green new growth.

Laid tapes and set 3 flags per plot as per previous page each labeled 1, 2, or 3 so within plot "A1" = A1-1, A1-2, A1-3



2080

Percent cover and biomass will be difficult to obtain. Perhaps spread time while in the end of August. The ground is moist from recent rain but it was probably quite dry before that. Roadside grass and weeds also brown. Oddly, green and flowering Gallardia were found on the mulch path leading inward from road to plot.

A 1m x 1m pvc square placed over each flag with the flag at the center. The square has been divided into 4 equal quadrants. Notes ~~a report~~ will be taken in general at each location. Plot biomass will be obtained from ~~the~~ one of the every ¼ quadrants.

A1-1 Little grass, some scattered wiregrass sparse and spread

coverage <5%
<5%
<5%
<5%

A1-2 <5%
5-10%
<5%
<5%

A1-2 has more wiregrass than A1-1 but still <5% coverage

J-11

A1-3 5-10%
5-10%
5-10%
10-15%

A1-3 fell within a Tall, dense patch of wiregrass atypical of plot.

C1-1 Evidence of grass which is now senesced. Grass canopy was very good before senescence. Around No wiregrass
25%
15%
15%
35%

C1-2 some wiregrass mixed with dry grass.
40%
30%
30%
25%

C1-3 More wiregrass and less other grass than C1-1 or C1-2
40%
25%
30%
25%

B1-1 mixture of wiregrass & dry grass
15%
30%
30%
30%

B1-2
.1%
2%
25%
10%

Dry plant grass w/ occasional wiregrass unevenly distributed

B1-3 5%
30%
20%
35%

A lot of dry grass, some wiregrass

E1-1 — Lots of THC, vigorous wiregrass. Good evidence of dry grasses and large dead
35%
30%
30%

C1-2 - Dry, mostly wiregrass (harvested plot in least done).

50%
50%
40%
30%

E1-3

20% — DARK MIXTURE of JUNCUS
20% — & DEAD GRASS
20%
30%

D1-1

<5% — This plot less done than
<5% — part of D1. D1-1 has
<5% — very sparse Juncus &
<5% — minimal dry grass.

D1-2

10% — Mostly wiregrass, [illegible]
10% — other grass
10%
15%

D1-3 - Thicker than other [illegible], mostly
10% — wiregrass. [illegible]
15%
15%
15%

B2-1 - MIXTURE OF WIREGRASS & DEAD
PLANT MATERIAL ([illegible])

20%
25%
30%
35%

B2-2 Mostly wiregrass — B2-3

B2-2	B2-3
15%	15
15%	20
25%	15
20%	20

~~Back~~ at hotel ≈ 6:30 P.M. Beginning to rain lightly.

9/17/9. Left [illegible]

([illegible])

A2-1

A2-1 only [illegible]. All D2 only, S[illegible] very sparse, although thicker/denser in NW corner near underlying A2-1.

15%.
20%.
15%.
15%.

A2-2 sparse [illegible]

5%.
<5%.
5%.
<5%

A2-3 SPARSE [illegible]

<5%
<5%
<5%
<5%

D2-1 D2 adjacent [illegible] along west [illegible]. D2-1 (TRANSITIONS) and D2-2

15%
15%
15%
15%
>5%

D2-2

15%.
10%.
10%.
15%

D2-3

5%.
<5%.
<5%.
<5%.

E shows more [illegible], with more evidence of [illegible] grasses, [illegible] than the [illegible] 25" [illegible]

E2-1.

15%.
15%.
15%.
20%.

E2-2

15%.
15%.
15%.
15%.

E2-3

<5%.
10%.
15%.
10%.

C = Dense & diverse native wiregrass & dry grass

C2-1 15%
25%
25%
25%
25%

C2-2 mainly wiregrass but good amount of dry ~~dead~~ grass & [illegible]

25%
25%
30%
30%

C2-3
20%
5%
10%
15%

E3s = sparse wiregrass but abundant senesced gra.

E3-1
5%
20%
10%
15%

E3-2
50%
5%
<1%
35%

A lot of wiregrass but senesced grass too

E3-3 10%
35%
20%
25%

B3. SW portion spot very little wiregrass but a lot of senesced grass (ie B3-2). NE corner of plot heavier in wiregrass (incl. B3-3). ~~B3~~ B3-2 = wiregrass senesced grass

B3-1	B3-2	B3-3 (mostly wiregrass)
10%	5%	10%
15%	10%	30%
20%	30% (sen. [illegible])	30%
15%	20% (senesced)	25%

C3-0
Even mixture of senesced grasses & irregularly scattered wiregrass. [illegible]

C3-1 (more senesced grass)	C3-2	C3-3
5%	5%	20%
30%	15%	15%
20%	15%	20%
15%	15%	20%

D3 = SPARSE, poor coverage overall

D3-1
5%
<5%
5%
~~5%~~

D3-2
<5%
<5%
<5%
<5%

D3-3
<5%
<5%
<5%
<5%

A3 SPARSE, SCATTERED WILLOWS + some [illegible] grass

A3-1	A3-2	A3-3
<5%	5%	10%
5%	<5%	<5%
10%	<5%	<5%
<5%	<5%	<5%

Returned None

9/24/[illegible]

Dry weight (GRAMS)

After drying for 24h at 70C.

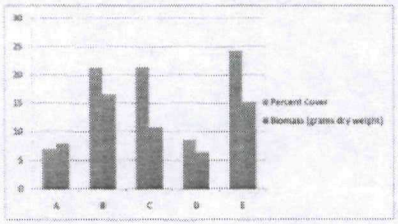
A1-1	0.4	A2-1	9.2	A3-1	6.1
A1-2	25.8	A2-2	10.2	A3-2	3.0
A1-3	14.6 (14.6)	A2-3	1.4	A3-3	0.7
B1-1	15.6	B2-1	39.6	B3-1	9.7
B1-2	7.4	B2-2	30.8	B3-2	4.2
B1-3	13.9	B2-3	5.0	B3-3	22.6
C1-1	12.8	C2-1	21.2	C3-1	4.2
C1-2	[illegible]	C2-2	3.5	C3-2	8.0
C1-3	16.4	C2-3	6.3	C3-3	13.8
D1-1	2.2	D2-1	9.4	D3-1	1.7
D1-2	10.3	D2-2	11.8	D3-2	1.9
D1-3	18.3	D2-3	1.6	D3-3	0.7
E1-1	25.7	E2-1	16.0	E3-1	4.8
E1-2	15.8	E2-2	17.8	E3-2	28.3
E1-3	1.2	E2-3	3.6	E3-3	23.7

September 2009 percent coverage data for subplots at the Lower Silver Creek Pilot Study (Park City, Utah)
WARD 300

	AVG						AVG						AVG						AVG						AVG				
A1-1	5	5	5	5	5	B1-1	26.25	15	30	30	30	C1-1	22.5	25	15	15	35	D1-1	5	5	5	5	5	E1-1	33.75	35	30	40	30
A1-2	6.25	5	10	5	5	B1-2	17.5	10	25	25	10	C1-2	31.25	40	30	30	25	D1-2	11.25	10	10	10	15	E1-2	42.5	50	50	40	30
A1-3	11.25	10	10	10	15	B1-3	28.75	30	30	20	35	C1-3	30	40	25	30	25	D1-3	13.75	20	15	15	15	E1-3	22.5	20	20	20	30
A2-1	13.75	15	10	15	15	B2-1	27.5	20	25	30	35	C2-1	22.5	15	25	25	25	D2-1	15	15	15	15	15	E2-1	16.25	15	15	15	20
A2-2	5	5	5	5	5	B2-2	18.75	15	15	25	20	C2-2	27.5	25	25	30	30	D2-2	12.5	15	10	10	15	E2-2	15	15	15	15	15
A2-3	5	5	5	5	5	B2-3	27.5	15	20	15	20	C2-3	12.5	20	5	10	15	D2-3	5	5	5	5	5	E2-3	10	5	10	15	10
A3-1	6.25	5	5	10	5	B3-1	15	10	15	20	15	C3-1	17.5	5	30	20	15	D3-1	5	5	5	5	5	E3-1	12.5	5	20	10	15
A3-2	5	5	5	5	5	B3-2	16.25	5	10	30	20	C3-2	12.5	5	15	15	15	D3-2	5	5	5	5	5	E3-2	43.75	50	50	40	35
A3-3	6.25	10	5	5	5	B3-3	23.75	10	30	30	25	C3-3	16.25	20	15	15	15	D3-3	5	5	5	5	5	E3-3	22.5	10	35	20	25
AVG:	7.083333						21.25						21.38889						8.611111						24.30556				
STDV:	5.186847						5.303301						7.165576						4.394796						12.74925				

Dry weights (grams) from September 2009 obtained from 1/4 of 1 meter square.

A1-1	0.4	B1-1	15.6	C1-1	12.8	D1-1	2.2	E1-1	25.7					
A1-2	25.8	B1-2	7.4	C1-2	11	D1-2	10.3	E1-2	15.4					
A1-3	14.6	B1-3	13.9	C1-3	16.4	D1-3	18.3	E1-3	1.2					
A2-1	9.2	B2-1	39.6	C2-1	21.2	D2-1	9.4	E2-1	16					
A2-2	10.2	B2-2	30.8	C2-2	3.5	D2-2	11.8	E2-2	17.6					
A2-3	1.8	B2-3	5	C2-3	6.3	D2-3	1.6	E2-3	3.6					
A3-1	6.1	B3-1	9.7	C3-1	4.2	D3-1	1.7	E3-1	4.8					
A3-2	3	B3-2	4.2	C3-2	8	D3-2	1.9	E3-2	28.3					
A3-3	0.7	B3-3	22.6	C3-3	13.8	D3-3	0.7	E3-3	23.7					
AVG:	7.933333		16.58333		10.8		6.433333		15.21111					
STDV:	8.290507		12.22426		5.889609		6.229767		10.00368					



Percent Cc Percent Cover

Treatment	AVG	STDV
A	7.08	3.19
B	21.25	5.3
C	21.39	7.16
D	8.61	4.39
E	24.3	12.75

Biomass (g)

Treatment	AVG	STDV
A	7.93	8.29
B	16.53	12.22
C	10.8	5.89
D	6.43	6.23
E	15.21	10

Treatment	Percent Cc	Biomass (grams dry weight)
A	7.08	7.93
B	21.25	16.53
C	21.39	10.8
D	8.61	6.43
E	24.3	15.21